National Aeronautics and Space Administration

PLANETARY PROTECTION ADVISORY COMMITTEE

June 10–11, 2004
NASA Headquarters and Lowe's L'Enfant Plaza Hotel
Washington, DC

MEETING REPORT

John D. Rummel
Executive Secretary

Norine E. Noonan
Chair

PLANETARY PROTECTION ADVISORY COMMITTEE (PPAC)
NASA Headquarters and Lowe's L'Enfant Plaza Hotel
Washington, DC
June 10–11, 2004

Meeting Minutes
Table of Contents

Thursday, June 10, 2004 ***2***

Welcome and Meeting Overview 2
Planetary Protection Program Update 2
Annual Ethics Briefing 2
Solar System Exploration Overview 2
Current Status, ESA Missions 3
Communications Planning for the Office of Planetary Protection 4
Mars Technology Program and Planetary Protection 6
The Vision for Space Exploration 7
Space Microbiology and Human Mission 8
Discussion of Future Planetary Protection Challenges 9
Status of Planetary Protection Molecular Methods and their Application 10

Friday, June 11, 2004 ***11***

Introduction to Discussion on Planetary Protection Standards 11
Historical Overview of Forward Contamination Standards 11
Committee Discussion on Standards 12
Mars Sample Return Requirements 13
Results from MER and other Mars Missions 14
NRC Mars Forward Contamination Study Status 14
Status of MSL Planetary Protection Categorization 14
Discussion of Mars Requirements and MSL Planetary Protection 16

Appendix A Agenda
Appendix B Planetary Protection Advisory Committee Membership
Appendix C Meeting Attendees
Appendix D List of Presentation Materials and Distributed Materials

Meeting Report Prepared By:
Robert J. Katt, Consultant
INFONETIC

PLANETARY PROTECTION ADVISORY COMMITTEE (PPAC)
NASA Headquarters and Lowe's L'Enfant Plaza Hotel
Washington, DC
June 10–11, 2004

Thursday, June 10, 2004

Welcome and Meeting Overview
Dr. Norine Noonan, chair of the PPAC, called the meeting to order and welcomed the committee members, representatives from Federal agencies and international representatives, and other meeting attendees. She announced that the second day of the meeting would be held at the Lowe's L'Enfant Plaza Hotel because of the Federal holiday in observance of President Reagan's funeral. Dr. Noonan and Dr. John Rummel, the Executive Secretary of the PPAC, reviewed the agenda and objectives of the meeting.

Planetary Protection Program Update
Dr. Rummel reviewed the significant events relevant to planetary protection since the January meeting. The Planetary Protection Practitioners Course has been conducted twice since January, once in California and once in Basle, Switzerland. Dr. Rummel discussed the planetary protection interests in the arrival of the Cassini spacecraft at the Saturn system, including the Huygens probe to Titan. The Mars Exploration Rover (MER) Opportunity has made discoveries at its Meridiani Planum site on Mars that are significant for planetary protection issues associated with future Mars Exploration Program missions.

Annual Ethics Briefing
Andrew Falcon from the NASA General Counsel's Office gave the mandatory annual ethics briefing for advisory committee members as Special Government Employees (SGEs). An SGE was defined in the U.S. criminal code as part of the ethics codification in 1962. Mr. Falcon reviewed the basic ethics principles underlying the statutory requirements. Sections 203 and 205 of Title 18 of the U.S. Code prohibit representational activities before the Government. Section 208 prohibits involvement in a particular matter where there is a personal financial interest. This section does not require involvement of parties, and the interest of an SGE's employer is imputed to the SGE. Mr. Falcon stressed that members should contact the Executive Secretary first, with an ethics counselor from the General Counsel's Office as a backup, if an issue arises that might fall under any of the statutory prohibitions.

Solar System Exploration Overview
Andrew Dantzler, Deputy Director of the Solar System Exploration Division (SSED), Office of Space Science, discussed activities in his division in the context of the 2005 President's budget request. He reviewed key events in the SSED from September 2003 through December 2004 and the goals of the national vision for U.S. space exploration. SSED's strategic roadmap fits well with the goals of the vision. Lunar exploration activities will include a series of robotic missions starting no later than 2008, with a first extended human expedition possibly as early as 2015. The Moon will be used as a testbed for technology to be used in subsequent human exploration of Mars.

The science components of Project Prometheus and the Jupiter Icy Moons Orbiter (JIMO) mission, including radioisotope power system (RPS) technology, have been transferred to the SSED. All other components of Project Prometheus have moved to the new Office of Exploration Systems (Code T). Mr. Dantzler summarized the objectives and status of the Stardust, Genesis, MESSENGER, Deep Impact, Dawn, Kepler, and New Horizons missions. The second New

Frontiers mission will be selected in the next few weeks. A Discovery Program Announcement of Opportunity (AO) was released in March 2004, with proposals due in July. The launch of JIMO is now scheduled for not earlier than 2015. Cassini orbit insertion at Saturn will occur on July 1, 2004.

For the Mars Exploration Program, Mr. Dantzler provided updates on the Mars Global Surveyor, Odyssey, and MER operational missions. Missions in development include the Scout Program's Phoenix mission in 2007 and the Mars Telecommunications Orbiter in 2009. The PPAC asked about budget implications of mission extensions. The goal of the 2009 Mars Science Laboratory (MSL) mission is to "search for habitable environments and signs of building blocks of life." Roving and other operational activities planned for the MSL depend on its RPS power source of several Multi-Mission Radioisotope Thermoelectric Generator (MMRTG) units.

With respect to the new Lunar Exploration Program, the 2009 mission is not planned yet. The SSED is trying to maintain the schedule in the exploration vision for the Lunar Robotic Orbiter (LRO) mission in 2008. A Lunar Exploration Program Office has been established within the SSED. Dr. Rummel discussed planetary protection categorization for lunar exploration and sample return. The Moon is exempted from NASA's planetary protection policy, but is Category I in the classification set by the international Committee on Space Research (COSPAR). Mr. Dantzler described the general approach to use of the Moon for work on planetary protection technology. He discussed potential planetary protection issues that might come before the PPAC when the selections for the Discovery and New Frontiers programs are made. The Genesis sample return is being used to examine survival of microbial populations in space. PPAC members asked about implications of using the Moon as a staging point for either Mars outbound or return voyages. Dr. John Kerridge voiced his concern about the impact of the exploration initiative on NASA's overall mission for scientific exploration.

Current Status of ESA Missions

Dr. Gerhard Schwehm, Head of ESA's Planetary Missions Division and the ESA representative to the PPAC, began with a summary of ESA missions in the past year: Mars Express, Smart-1, and Rosetta. The Venus Express mission is scheduled to launch in November 2005. He described the technical issues with the subsurface radar sounder (MARSIS) on Mars Express. MARSIS may be deployed for operation in mid-July, but it may be delayed further. Mars Express is now in the science exploitation phase. Dr. Schwehm listed the Mars Express scientific objectives and the instruments that will be employed to achieve them. Scientific highlights of Mars Express include break-through science on water-ice mapped at the martian south pole, observation of very young volcanic processes, and detection of methane in the atmosphere. Mars Express also has performed a list of scientific "firsts" including details of carbon dioxide fluctuations in the atmosphere, water vapor and ozone distribution, observation of erosion attributed to liquid water seepage and higher-resolution imaging of the surface. The Mars Express primary mission has been approved through 2005. An extension for one martian year will be requested.

ESA has officially declared that the Beagle 2 lander failed. Beagle 2 was a COSPAR Category IVa mission. The PPAC discussed implications of the Beagle 2 inquiry board report being published in full or remaining unpublished. Dr. Schwehm described some of the recommendations, which were released in May 2004, and their implications for future missions. It may be possible to locate Beagle 2's parachute with Mars Express.

The Rosetta mission to comet 67P/Churyumov-Gerasimenko will take 10 years to reach the comet. Its MIRO instrument has already been used to photograph a comet within the solar system.

As part of the ESA reorganization, the Directorate of Manned Spaceflight and Microgravity has been renamed the Directorate of Human Spaceflight and Exploration. The new ESA Director will take charge in September 2005. The Aurora Programme is now called Exploration, but the initiative is not yet funded. Program approval will not be decided until mid-2005. The ESA Council will decide on a bridging phase in June 2004. ESA is considering participating in NASA's MSL mission by providing instrumentation. ESA is developing standards for back contamination. A study of spacecraft cleanliness (for forward contamination) was conducted using samples taken from the Rosetta spacecraft at the Kourou launch site.

The PPAC expressed interest in the terms of reference for ESA's Planetary Protection Working Group and Planetary Protection Ethical Working Group. Dr. Schwehm said that the groups do not have formal terms of reference, but Dr. Margaret Race, who is the U.S. participant, can probably inform the PPAC on the groups' scope of activities. PPAC members discussed with Dr. Rummel the content of the Planetary Protection Practitioners Course as it was given in Basle, compared with the content of the version given in the United States. The common basis is the COSPAR policy. Dr. Schwehm described the concept studies done for the Aurora (Exploration) Programme and a provisional series of missions that has been put forward. The technology will be driven by the challenge of getting humans to Mars. Germany is seeking a separation of space science from engineering development and human space exploration. ESA faces other issues in funding its Mars exploration program.

In response to Dr. Rummel, Dr. Schwehm said that the ESA Exploration Programme will embrace additional missions to the outer planets beyond Rosetta. Because Europe does not have radioisotope thermoelectric generator (RTG) or nuclear electric propulsion (NEP) technology, ESA will need to consider participating in JIMO, perhaps by coordinating ESA investigators involved in the project. Dr. Rummel noted that space agencies often face a management challenge in discerning where instruments are principally being developed, so that coordination responsibility can be decided.

Dr. George Robinson asked if there were any recent authoritative references on the debate between robotic missions and human missions for achieving science objectives in space. The responses from staff and PPAC members indicated that there were varying views on the subject. The most current authoritative document may be the *Report of the Advisory Committee on the Future of the U.S. Space Program* (December 1990, Norman Augustine, chair; available at <www.hq.nasa.gov/office/pao/History/augustine/racfup1.htm>). Dr. Schwehm agreed to look for any ESA documents on the subject.

Communications Planning for the Office of Planetary Protection

Linda Billings of the SETI Institute updated the PPAC on the draft risk communication plan and communication strategy for the Office of Planetary Protection. The communication plan and strategy will serve as informal guides rather than as strict protocols. There is now an official NASA Planetary Protection website. Articles written by Dr. Rummel and Ms. Billings have appeared in *Space Times* and *Space Policy*, and Ms. Billings has presented a paper on planetary protection communication research activities to the International Communications Association. Dr. Race and Ms. Billings have joined the NASA Astrobiology Institute Science Communications Working Group, which is currently developing a charter to define its scope and objectives.

Ms. Billings distributed to the PPAC a one-page summary of the draft risk communication plan for planetary protection. The plan, which includes statements of scope, goals, and guiding principles, is similar in format and scope to other Office of Space Science risk communication plans. It also draws on on NASA risk communication documents prepared by the Jet Propulsion Laboratory (JPL) Risk Communication Coordinator. Its purpose is to coordinate NASA's approach to planetary protection risk communications by clarifying and codifying the approach. The section on roles and responsibilities is specific about individuals' communication roles in different circumstances, as it is important to have contingency planning done before an incident occurs. Ms. Billings discussed the difference in roles for an incident contingency team, compared with the role of a citizen advisory board in airing local concerns in advance of an incident.

In response to a PPAC question, Ms. Billings agreed that the plan should not be limited to back contamination issues. She will review the draft to ensure that it applies to both forward and back contamination risk communication issues. The draft risk communication plan will be sent to the PPAC members and NASA personnel for review. Dr. Levy asked how the risk communication effort articulates the theme that international planetary protection protocols are grounded in protecting planetary environments for scientific objectives, as opposed to preserving planetary environments in a pristine state. Dr. Rummel replied that Dr. Race and coauthors have published on this point. However, there is a need to distinguish between current policy and issues that may influence policy in the future. At the next PPAC meeting, Dr. Laurie Zoloft, a PPAC member, will make a presentation on the current and prospective basis of planetary protection. In response to a question on environmental impact documents for Mars sample return (MSR), Dr. Rummel reviewed the major issues in preparing for sample return and establishing a containment facility to investigate returned samples. The safety concerns need to b addressed without becoming overly theatrical or arousing suspicions among the public that NASA is hiding something.

The PPAC discussed the role of the JPL Risk Communication Coordinator as a central point for space exploration risk communication. A NASA procedures document that covers this role is currently being revised. Dr. Robinson asked about recent articles that address the legal aspects of risks associated with back contamination. He noted that several papers recently published in the professional risk management literature argue that, although NASA has good paperwork on risk management, the *Columbia* accident shows the paperwork does not reflect real risk management in practice. Ms. Billings replied that a frequent problem in risk communication is getting officials to adhere to the policy and procedure when these have been planned and accepted prior to an incident. It is essential to establish the practice of public involvement and participation before an incident occurs. Dr. Rummel said that NASA's internal review of the legal aspects was updated in the past several years specifically to include returned samples. The ESA has recently completed a study of international law associated with planetary protection. Dr. Susanna Priest noted the value in the work being done by Ms. Billings and Dr. Race to compile the literature on public participation programs. Bringing all the relevant sources together is difficult because of the range of venues in which sources are published. Dr. Noonan recommended that the education and public outreach (EPO) coordinator assigned for each Office of Space Science mission should be educated on maintaining a two-way dialogue on any planetary protection issues involved with the mission. The mission's EPO coordinator is likely to be the first person many members of the press or public turn to for information when an incident occurs, rather than the Office of Planetary Protection. Dr. Rummel agreed with the importance of involving the EPO coordinators and described the current working relationships and continuing involvement of his office with the EPO staff of the Mars Exploration Program. Dr. Schwehm described how ESA manages communication with the press and public during an incident.

Dr. Robinson recommended that planetary protection and EPO activities also need to be coordinated with the NASA Office of General Counsel, as legal issues may be more important in avoiding legal obstruction to a launch than strictly ethical concerns. In response to a question from Dr. Carolyn Griner, Dr. Rummel described the working relationship between the Office of Planetary Protection and Project Prometheus on activities now in Code T. Dr. Noonan stressed the importance of pursuing dialogue with Code T on planetary protection issues related to space exploration activities.

Mars Technology Program and Planetary Protection
In introducing Dr, James Cutts, Chief Technologist for the SSED, Dr. Rummel noted that much of the technology development work that has been done recently for planetary protection has been supported by the Mars Exploration Program in SSED. Dr. Cutts began with the historical context for current activities. For Viking, the entire spacecraft had to be designed around dry heat sterilization as the means to control forward contamination. After the initial investments in planetary protection technology during the Viking era, investment in technology development did not resume until late in the 1990s. This resumption was motivated by preliminary planning for a sample return mission to Mars in the 2003–2005 time frame. Although some activity has continued under the Mars Technology Program, it was descoped in 2001 when the schedules for MSL and a subsequent sample return mission were extended. The postponement led to a major reduction of sample return technology efforts, with staff transferred to other areas.

In the past 5 years, about $24 million has been invested in planetary protection technology development for Mars exploration. The work has been sponsored by the NASA Planetary Protection Office, Mars Technology Program, Small Business Innovation Research (SBIR), NASA Center funds for discretionary research, and individual flight projects. For each fiscal year (FY) from FY 1999 to FY 2004, Dr. Cutts presented funding levels by sponsor and area of application. If the MSR program had not been radically descoped, the technology development spending in back contamination control would have grown quickly to between $5 million and $8 million per year. The work done since 1999 provides a foundation for forward contamination control technology for the Phoenix, MSL, and MSR missions and for back contamination control technology for sample return. Dr. Cutts emphasized that development work on systems technologies and analytical capabilities, such as probabilistic risk assessment (PRA), is just as important as development of the component technologies.

Dr. Cutts described the culture of the Mars Exploration Program as having undergone a paradigm shift in how planetary protection is viewed. It is now accepted as a crosscutting discipline that affects broad architectural elements such as mission design; entry, descent, and landing (EDL); and sample handling. Planetary protection is now one of 13 high priority technology elements in the SSED technology roadmap. A key principle is that planetary protection technology enables NASA to undertake missions to biologically interesting targets. It also helps reduce cost and risk. Investments in planetary protection technology must yield tangible benefits for the mission. In short, planetary protection is now a “way of life” in solar system exploration. Recent discoveries on MARS imply significant potential for indigenous habitability, which will be investigated by future in situ missions.

The Exploration Initiative has renewed the commitment to MSR and thus to the technology needed to control back contamination, including a Mars Returned Sample Handling (MRSH) Facility. Planetary protection challenges in upcoming missions include the 2007 launch of Phoenix, which will be the first U.S. mission in the new COSPAR category IVc. Planetary protection issues for MSL include planning for new levels of organic cleanliness, the need to respond to concerns about Mars special regions, and complexities raised by use of a nuclear power system on the rover (particularly off-nominal landing that could affect or create a special region). The MSL project is currently developing a planetary protection implementation strategy (briefed to the PPAC on Thursday by Dr. Michael Meyer).

Dr. Cutts also reviewed the planetary protection challenges associated with the directed missions, which are new Mars missions resulting from the Exploration Initiative. These missions could include a sample return in 2013, the Astrobiology Field Laboratory, a Deep Drill Lander, and a range of possibilities for competed Scout missions with varying implications for planetary protection. Forward contamination challenges will increase as more in situ missions go to biologically interesting sites. Back contamination issues will increase, and infrastructure for MRSH will be necessary. Dr. Cutts reviewed the current set of quantitative design guidelines for MSR planetary protection requirements and the implementation implications of those guidelines. The existing implementation methods rely on technology developed for Viking, and new technology is needed to meet many of the guidelines. Dr. Cutts listed current technology task areas that respond to the new programmatic and policy drivers since 1998, as well as areas that may provide technology solutions for emerging needs. Some of these current task areas are being covered under Advanced Development for the Mars Exploration Program; others are being undertaken within the Mars Technology Program. As an example, he described work on process certification for hydrogen peroxide sterilization. A decision on operational use of this technique is expected by FY 2005. Other examples are the rapid spore bioburden assay, bioassay certification of enzyme-based assays, and the organic cleanliness environment for MSL. The NASA Research Announcement (NRA) in the spring of 2003 did not include back contamination control. It did cover forward contamination control and sample handling systems for sample return. Dr. Cutts reviewed each of the projects being done at JPL, some with academic co-investigators. The PPAC discussed the NASA and JPL emphasis on hydrogen peroxide for microbial burden reduction, in light of different choices for sterilization techniques being made in other fields.

In response to Dr. Noonan's question on the most serious technology challenges in meeting planetary protection needs, Dr. Cutts said that sample return in 2013 from the Mars surface is the most challenging. Techniques are needed to prevent back contamination (e.g., breaking the chain of contact with Mars), and the MRSH facility must be ready by then. Validation of technologies to the level of reliability required is another major challenge. Dr. Cutts listed other challenges in meeting planetary protection guidelines for Mars and for outer planet exploration. An SSED report on outer planet planetary protection is due in September 2004. In his summary, Dr. Cutts emphasized the value of building a framework for planetary protection technology development that is more robust to programmatic changes than the current approach.

The Vision for Space Exploration

Dr. Michael Lembeck, Director of the Requirements Division in the Office of Exploration Systems, began with the objectives and major milestones of the new vision for space exploration. Code T interprets the major milestones as constraints on the program: things that Code T must do. Reasons for going to the Moon include (1) using it as a test bed to reduce risk and to test technologies for future human Mars mission and (2) investigating the Moon's potential for resource utilization. The requirements for lunar human missions are beyond those done with Apollo-era technology, which is why an extensive technology development effort is required before the first human mission.

Dr. Lembeck described how Code T management is using the lessons and findings from Department of Defense (DoD) advanced system development experience and the *Columbia* Accident Investigation Board (CAIB) report. The three divisions within Code T are Business Operations, Requirements, and Development Programs. Code T's answer to requirements creep is to implement a spiral development process for exploration systems. Dr. Lembeck also described the flow of exploration systems development from high-level strategy to development tasks to technology products. Dr. Noonan asked where the feedback loops occur in the process as outlined, as feedback is essential to spiral development. Dr. Lembeck replied that the feedback loops are inherent in the process and would be visible in a more detailed level of exposition of the process flow than shown in his overview diagram. The first spiral of development will include the prototype and first two blocks of an operational Crew Exploration Vehicle (CEV).

Dr. Lembeck next described the acquisition strategy for the Constellation Program. Early concept definition is being done through a Request for Information (RFI) to industry and the NASA Centers in support of Projects Constellation and Prometheus requirements development and acquisition. Another Code T effort is the Centennial Challenges, which will seek innovative approaches to the major hurdles facing exploration. Challenges in this series will be initiated in annual cycles. Code T is still being staffed up, but its level 0 and level 1 requirements have been approved by the Joint Strategic Assessment Committee. A preliminary acquisition strategy is being implemented through the RFI and the Prometheus Broad Area Announcement for technology maturation, which will be released by June 30, 2004. In closing, Dr. Lembeck repeated the them that Code T is making exploration systems affordable and sustainable by using a technology building block approach and spiral development, together with disciplined acquisition management. NASA and Code T will be working to align programs with the recommendations from the President's Commission on Space Exploration.

Discussion topics included the difference between the CEV and space vehicles for cargo and the differences between Code T's spiral development process and past ways of develop space transportation systems. Dr. Lembeck agreed with the suggestion that the Mercury, Gemini, and Apollo programs can be viewed as constituting three spirals of a spiral development process. Dr. Kerridge asked what was the focused goal for human spaceflight, and Dr. Lembeck answered that it was exploration. He discussed with PPAC members the similarities and differences between the current context for exploration and the drivers of Earth exploration during the Age of Exploration in the fourteenth through seventeenth centuries. Dr. Lembeck said that planetary protection considerations for Code T programs are being addressed through internal connections between the Requirements Division in Code T and other offices in the Agency that set constraints and requirements. Dr. Rummel said he would be contacting Code T personnel on planetary protection issues. Planetary protection issues related to JIMO were incorporated by JPL into the JIMO Request for Proposal (RFP).

The PPAC discussed the implications of eventual human exploration missions to Mars for current planetary protection requirements and burdens on missions. The PPAC agreed with the point, made in a 1992 National Research Council (NRC) report, that human exploration will almost certainly result in unavoidable forward contamination of areas that humans visit. A major consideration should be ensuring that near-term goals for science-driven robotic missions are pursued. Particularly important is the search for definitive scientific evidence on the question of whether extant life exists on Mars now. The PPAC agreed with Dr. Carlé Pieters' suggestion that NASA needs to integrate its science, exploration, and protection objectives into a coherent set of goals. Dr. Noonan noted that the NASA Advisory Council (NAC) has requested that the specialized advisory committees, including the PPAC, provide comments to the NAC through their chairs on the impact of the Exploration Initiative on areas under each committee's purview.

Space Microbiology and Human Mission

Dr. Elaine Akst of the Office of Biological and Physical Research (OBPR), briefed the PPAC on microbial studies being conducted in OBPR. The microbial monitoring currently being conducted on the International Space Station (ISS) is for human health assessment of the crew. OBPR microbial research is solicited to address human health risks identified in the OBPR critical path roadmap. The questions posed in the roadmap are long term issues, although the individual studies to address them are typically only 3 to 4 years. (Copies of the critical path roadmap will be distributed to the PPAC members.) Dr. Akst described the six flight research projects and twelve ground research studies that are currently funded. A workshop was conducted at Kennedy Space Center in February 2004 to identify future research themes for microbial research on the ISS, consistent with the critical path roadmap. Goals from workshop were used to develop research targets for the most recent set of NRAs for ground-based research. NASA is considering creation of an archive of microbial samples taken from the ISS. In May 2005, ESA will conduct a workshop in Belgium on microbial research.

Two of the four major research goals identified by the February workshop are to achieve functional stability of low-virulence microbial communities in a closed ecosystem and understand the rate of species turnover in space environments. Dr. Colleen Cavanaugh said these two goals reflect fundamental questions that environmental microbiology is still trying to answer for Earth ecosystems. A major challenge is just to identify all the species present in a microbial ecosystem. She asked if the workshop participants had discussed how to study species turnover and community stability, if the species present have not been comprehensively identified. Among the workshop suggestions, said Dr. Akst, was to take swab samples in the ISS and perform tests such as polymerase chain reaction (PCR) analysis, to get an idea of some of the species. Dr. Cavanaugh mentioned an experimental technique using on-slide DNA sequencing. Dr. Ronald Atlas said that, for microbes carried in humans, the percentage of identified species is better than the 1 percent identified in soil or water samples, but there are still many that are unknown. He noted that some of the fungi that have been found on the ISS have been associated with sick building syndrome on Earth. One challenge for on-orbit microbial studies has been that crew health data are not available to the researchers. Another is limited time available for recording details of crew activities relevant to microbial monitoring and research.

Discussion of Future Planetary Protection Challenges

Dr. Rummel used the Apollo 12 mission to illustrate why forward and back contamination are significant for space policy, as well as being scientific issues. The Apollo 12 crew retrieved a camera from Surveyor III, which had landed on the Moon two years previously. *Streptococcus mitis* was cultured from one of the 33 samples swabbed from the camera body after it was returned to Earth for study. This led to speculation that *S. mitis* had survived on the Moon for two years. An alternative interpretation, which Dr. Rummel accepts, is that the camera was contaminated during the return, storage, and inspection activities subsequent to its retrieval from Surveyor III. There are a number of questions about the handling and sampling procedures, and sterile protocol may have been broken.

The episode has major implications for future missions, said Dr. Rummel. First, the microbial aspects of a mission must be considered when planning for the return of materials from other planetary bodies. Second, better techniques are needed for detecting and identifying microbes on spacecraft. Third, human-associated contamination cannot be completely avoided by human space explorers. Dr. Rummel illustrated the potential impact of humans in the martian environment with a photograph of an Apollo astronaut walking on the Moon, surrounded by a cloud of water vapor visible in the UV light from the Sun.

Planetary protection issues raised by human exploration were addressed during a two-day workshop held in 2001 at Colorado State University. Individual workgroups addressed the major topics of protecting Mars and science, protecting the astronauts and their health, protecting Earth from back contamination, and preserving the operational capabilities of humans that make it worth sending them to Mars. Dr. Rummel presented the workshop’s findings and recommendations. Topics for a future workshop were also identified.

During discussion, the PPAC agreed that it should re-emphasize the point that, once humans are on the martian surface, it will be compromised for future investigation of whether there was extant life on Mars. Therefore, the robotic investigations prior to human exploration must attempt to answer that question. A second question to answer before humans land on Mars is whether Earth microbes can survive in martian environments where humans are likely to visit. The PPAC also discussed issues in knowing whether a returned sample is safe and the implications for human exploration of Mars if extant life is found there by robotic exploration. The scope and wording of advice from the PPAC to Dr. Weiler on these points were considered.

Status of Planetary Protection Molecular Methods and their Application

Dr. Rummel began this presentation by saying that NASA must move beyond reliance on culturable aerobic spores as the indicator of spacecraft bioburden. NASA has not been driving the development of new molecular methods of mcrobe detection, but it can make use of the work done for other purposes. The administrative procedure for adopting molecular methods of detection as aids to implementing Viking-level cleanliness will be codified this year. A future standard for adopting new methods is being developed, and the current NRC study committee on preventing contamination of Mars is likely to recommend that NASA establish a standard.

In the February 2004 workshop on molecular methods of bioburden assessment, subgroup topics were standard molecular methods and tracking microbial diversity. The first subgroup concluded that the detection methods based on assays for adenosine triphosphate (ATP) or limulus amebocyte lysate (LAL) are good supplements to the standard method, but they will not replace it. The subgroup developed a list of assays that should be considered for mid-term development (funded for completion in 3 to 5 years), and another list of detection methods for longer-term development.

The subgroup on tracking microbial diversity concluded that studies of microbial diversity are important to planetary protection for three reasons. (1) Knowledge of the types of microbes that may be exported to another planet or moon is essential to avoid false positives from in situ or sample return life detection efforts. (2) Specifications of biological cleanliness depend on reference microbes, and the selection of reference microbes should reflect actual microbial diversity. (3) For detection methods to serve as a challenge to microbial reduction methods, the detection methods must be able to detect the most resistant microbe present. In addition, tracking diversity is required not only to help determine the appropriate sterilization/cleaning procedures but also to understand survival and growth potential of microbes at target bodies. Tracking microbial diversity is also important for knowing what terrestrial microbes may be present, if the search for life is a mission goal (including sample return). This subgroup recommended an ongoing effort to build a global library of microbial species present in spacecraft assembly environments and spacecraft components. Microbe samples from spacecraft should be archived. The subgroup also suggested procedures to obtain a sufficient and representative inventory of microbial populations on spacecraft.

During the discussion of Dr. Rummel's presentation, Dr. Atlas suggested that the PPAC address the point that planetary protection standards are dynamic. NASA should avoid locking in a one-time standard as a permanent one. As an example, he said the day's discussions indicate that at some point in the course of exploring a planetary body like Mars, the standards should begin allowing for less stringent requirements. Dr. Rummel agreed that forward contamination standards evolve, rather than remaining static. However, to be implementable standards must be associated with a procedure for meeting them. He noted that the current NASA standard is not established by international treaty.

Friday, June 11, 2004

Introduction to Discussion on Planetary Protection Standards

Dr. Rummel reviewed issues raised during Thursday's discussions. On the question of back contamination, quantitative implementation standards are needed, even if the fundamental standard or underlying principle is qualitative. He explained that the presentation on the historical background of the current forward contamination standards provides a basis for the PPAC to consider whether the current policy should be changed.

Historical Overview of Forward Contamination Standards

Dr. Pericles Stabekis of the Windermere Group gave the presentation. The first formal statement of a planetary protection standard by COSPAR occurred in 1964 with COSPAR Resolution No. 26.5, which is included in COSPAR Information Bulletin No. 20. The standard, which was adopted as COSPAR policy in 1969, set a limit on the cumulative probability of contamination. This limit assumed that the period of biological exploration of the solar system would be just 20 years (ending in 1988) and there would be no more than 100 missions to or near planets during that period. This top-level quantitative limit was not changed to a qualitative limit until the 1980s. The top-level cumulative probability of contamination was allocated among the space-exploring nations, and each nation then suballocated a ceiling probability of contamination to its individual missions. Dr. Stabekis discussed the probability factors included in the basic guiding formula for probability of contamination (P_C):

$$P_c = N_0 \text{ x } \sum_i P_i \text{ x } P_I \text{ x } P_R \text{ x } P_G$$

in which N_0 is the total bioburden at launch, P_i represents a set of space survival parameters, P_I is the probability of impact, P_R is the probability of release, and P_G is the probability of growth. For Mars, P_G was assumed before the Viking mission to be 10^{-6}. After Viking, it was set lower, with the new estimate depending on the martian region. The P_i factor applies to atmospheric and other planet-specific environments, not to travel in space or microbial survival in surface environments. P_I varies from 1 for surface bioburden to 10^{-4} for buried bioburden without hard impact. The probability of Impact, P_I, is usually derived from the basic formula as a mission planning constraint. It has typically been 10^{-5} for launch vehicles, 10^{-4} for spacecraft.

Dr. Stabekis next described the current requirements for Mars orbiters and landers. Orbiters can meet either the P_I requirement set by the formula or a bioburden ceiling requirement. For Mars landers, the COSPAR subcategory classification depends on whether they have in-situ life detection experiments or are landing in a special region. Dr. Stabekis discussed with the PPAC the rationale for differences in requirements for landers with or without life detection experiments and the COSPAR subclassification for MARS landers. The current requirements assume that Mars could be locally contaminated but not globally contaminated. The extent of area that could be locally contaminated depends on whether it is a special region. The current requirements appear to assume a probability of growth in nonspecial regions of about 10^{-9} or 10^{-10} and in special regions of 10^{-3} or 10^{-4}. When these values are substituted into the formula for P_C, the resulting probability of contamination for special regions is several orders of magnitude higher than P_C for nonspecial regions and one to two orders of magnitude higher than P_C for orbiters. The P_C for special regions is also higher than the old quantitative limit of 10^{-3} for the cumulative probability of contaminating a planetary body of interest.

Given these divergences, Dr. Stabekis suggested that the PPAC consider the following points: (1) Is limiting the P_C of a planet of interest to less than 10^{-3} a reasonable overall guideline? (2) In the PPAC's view, are the current cleanliness standards for Mars landers appropriate? (3) What is an acceptable probability of hard impact for Mars landers? (4) Are current P_I requirements for Mars orbiters adequate?. Dr. Stabekis added that PPAC advice on these points would be useful for missions to Europa as well as for Mars orbiters and landers. The current practice is that projects are given quantitative requirements on spacecraft cleanliness to implement or they can meet the P_I requirement for orbiters. The top-level criterion is not quantitative, but the projects need to have an explicit, quantitative objective for noncontamination of the target site, toward which they can work.

In response to Dr. Noonan's question on what the current cleanliness requirements assume as the basis for bioburden counts, Dr. Stabekis said that all the requirements are measures of relative cleanliness. Historically they have been tied to the number of culturable spores. As sophistication of methods of identification and knowledge of organisms' ability to survive in different environments improves, it would be conceivable to have several standards for different types of organisms. In the past, such factors were considered through adjustments to the P_G factor. He does not believe the detection techniques have yet reached a level of sophistication where individual species can be targeted. Also, the knowledge of the environment at the target site is insufficient to quantify P_G across a variety of organisms and their resistance in that environment. On the interpretation of P_C, Dr. Stabekis said it indicates the probability of an organism becoming established in the environment at the target site, not the probability of an organism spreading over an entire planetary body.

<u>Committee Discussion on Standards</u>
Dr. Rummel opened the discussion by listing some considerations that were used historically as the basis for setting overall standards and that the PPAC may want to reconsider. One such assumption was the duration during which exploration missions should avoid establishing organisms on a planetary body(historically called the "period of biological exploration"). The reasons for preventing forward contamination were to avoid invalidating life detection experiments and to prevent the body from being overrun by terrestrial life, with consequent irreversible changes in its environment. One of the planetary protection issues for MSL is the period during which organisms should not become established and spread. For example, would local contamination of Mars be acceptable, if Mars stays dry until all the plutonium in the RTGs decays (so that organisms kept alive in an RTG-warmed, moist location would eventually die)? Dr. Rummel said this type of question is among those the MSL project is trying to assess.

The PPAC and Dr. Rummel discussed the duration for which contamination should be avoided, the accounting for cumulative P_C from previous missions (successful landings and crashes), the probability of global contamination of Mars if one site is contaminated, the consequences of potentially contaminating a single site of high scientific value, and the degree of international adherence to the COSPAR standards. Discussion of the status of work on culturable spores as an index of total microbial count (total bioburden for all microbial forms of life) led to related issues, such as using indicator organisms that have enhanced survivability beyond that of spores (e.g., ultraviolet-resistant strains or archaea). The probability factors used in estimating P_C or P_G were discussed with respect to the realism in the estimates for all the contributing factors and the need for realistic measures of the uncertainties in them.

The PPAC discussed issues in determining whether a life form found by a life detection investigation (in situ or from a returned sample) was of terrestrial (forward contamination) origin or indigenous to Mars. Another topic was balancing the interest in proceeding with investigations against the forward contamination risks. The consequences for both robotic and human missions of strong evidence for functioning biospheres on Mars (or another body) were considered. The members also discussed what kinds of advice, within the PPAC's scope, would be most effective in helping to shape and guide the robotic and human exploration programs as they continue to evolve.

A recurring theme in the discussions was the impact that the first human exploration of Mars would likely have on the ability to determine whether any life found there was of Earth or martian origin. The continuing sequence of robotic missions to Mars will also affect the ability to answer this "life on Mars" question. Dr. Noonan summarized the direction of the discussion as "How should we proceed with robotic missions and eventually human exploration, in a sequence that mitigates potential contamination, thereby preserving the ability to answer high-priority questions? The question about extant life on Mars will be the first one to be compromised by forward contamination. Planetary protection issues should be considered in the sequencing of science missions, including the data that may come back from missions for objectives that may inform and advance the notion of exploration."

Mars Sample Return Requirements

Dr. Rummel reviewed current missions with sample return (not from planetary bodies), the basic planetary protection considerations in sample return as formulated in past authoritative statements, the current requirements and design guidelines for a Mars sample return, and candidate procedure for sample handling of returned samples. The Stardust and Genesis missions were assigned COSPAR Category V (unrestricted Earth return) because the material being returned does not pose a biological risk to the Earth environment beyond what occurs naturally (from solar wind ions and interplanetary dust impinging on Earth atmosphere).

The MSR study team is working on a more constructive approach to addressing planetary protection issues of sample return, Dr. Rummel said. He summarized the current requirements, draft quantitative guidelines for mission design, and implementation considerations for three areas: (1) forward contamination, (2) inadvertent release of martian materials to Earth's biosphere, and (3) the basis for life detection protocols to determine if there are live, Earth microbes in a returned sample. The third area is important for preventing false positives in testing for martian life in returned samples. He outlined the study team's candidate sample handling process for MSR and the back contamination points that can be addressed in design and testing of each step in the candidate process. He then listed a set of questions about the release of returned samples from containment and suggested strategies for addressing the questions.

Dr. Noonan asked about the level of consideration by NASA and the Mars Exploration Program of containment and curation facilities, now that MSR has been brought back onto the planning horizon. Dr. Rummel referred to the three industry studies on MRSH facilities, which were briefed to the PPAC at its January 2004 meeting. If a decision on facility design is made this year or next, he said, there is time to prepare for samples arriving in 2016, including time for environmental impact studies, building the MRSH facility, and training staff to work in it. A prerequisite for that decision is completion of the MSR Protocol (now in draft form for public comment). Within NASA, the expectation is that the Mars Exploration Program will set up a MRSH Facility project and begin working on implementation. Dr. Rummel favors separation of sample handling for planetary protection from sample curation issues after a returned sample has been approved for release.

On the advanced robotics envisioned in the facility concept studies, Dr. Levy remarked that the present state of robotic technology can perform repetitive, assembly line–like operations well. However, the kind of flexible, adaptable robotics that science investigations such as those inside the MRSH facility will need are beyond the current state of practice. Dr. Rummel suggested that the PPAC consider the details of the quantitative guidelines for MRSH facility design and provide its advice to NASA. The members and Dr. Rummel discussed issues related to human error in handling biohazards, such as a recent accidental mailing of live anthrax spores, as they affect planning for a MRSH facility and planetary protection investigation of samples within it.

Results from MER and other Mars Missions
Dr. Michael Meyer from the Mars Exploration Program briefed the PPAC on results from the MER mission, with emphasis on those indicating the importance of abundant water in Mars' geologic past. At the Gusev site where Spirit landed, the Mőssbauer spectrum of the rock named "Adirondack": established that it was basaltic. Dr. Meyer discussed findings during Spirit's traverse to the Bonneville crater and then to the Columbia Hills. Spirit found more magnesium sulfate in trenches it dug with its wheels on the intercrater plains. This finding suggests underground water percolation. Spirit is now at the base of the Columbia Hills.

At Meridiani Planum, the rover Opportunity landed in a small crater with exposed bedrock below the crater rim. One reason for selecting Meridiani Planum as a MER landing site was evidence from the Mars Global Surveyor that it might have hematite. Analysis of the Meridiani soil confirmed that it contained hematite (primarily in the "blueberries"). The outcrop is not hematite, but the area near it is. Where the airbags bumped the martian surface, the hematite-rich "blueberries" were pushed beneath the dust. Sulfur, chlorine, and bromine in the outcrop indicate that the rock was once in water, but the results do not establish the rock's origin. Other features of the outcrop indicate it is sedimentary. Chemical analysis of bounce rocks outside Eagle Crater match the chemistry of SNC meteorites (found on Earth), confirming the hypothesis that the SNC meteorites came from Mars. (A martian origin was previously indicated by gas analysis of SNC meteorites.)

The rovers are entering the martian winter now, with reduced insolation for solar power and lower temperatures that reduce solar panel conversion efficiency. Thermal cycling problems may lead to battery failure. Dr. Meyer discussed with the PPAC the interpretation of the blueberries and weathering of the Jarosite rock from which they originate. Jarosite forms in acidic conditions.

Dr. Noonan recognized the PPAC members who are rotating off the committee. Certificates of appreciation were presented to Dr. Kerridge and Dr. Wall.

NRC Mars Forward Contamination Study Status
Dr. Pamela Whitney, the study director for the current NRC Committee on Preventing the Forward Contamination of Mars, briefed the PPAC on the study's status. A previous NRC study on forward contamination was published in 1992. Dr. Whitney described the constitution of the committee and its revised statement of task. The committee has met twice so far, once in Washington, DC, and once on the West Coast. Two more meetings are scheduled for August and December. The reporting writing process is underway, and prepublication release is expected in late 2004 or early 2005. The study's sponsor is the NASA Office of Planetary Protection. In response to a PPAC question, Dr. Whitney said that the committee understands that human exploration is a potential issue, but it will not be exploring that topic in depth because it is not in the statement of task.

Status of MSL Planetary Protection Categorization
Dr. Meyer, who is also the MSL Program Scientist, briefed the PPAC on COSPAR categorization issues related to the MSL. The question for MSL, he said, is how to investigate potential habitat for life (past or present) on Mars. MSL continues the succession of habitat investigation missions that includes the Mars Reconnaissance Orbiter (MRO) in 2005, the Mars Telecommunications

Orbiter in 2009, and the 2007 Phoenix/Scout mission. These missions will inform decisions on the Exploration Pathway choices made for the Next Decade missions after 2009.

The MSL rover will include an analytical laboratory. Its drilling and digging capabilities are still to be determined. The RFP for the sample handling system has not been released, but Dr. Meyer anticipates MSL will have some coring capability. MSL will require propulsive landing, rather than relying on airbags, because of its size and to allow precision landing at a site where there may be potentially dangerous terrain. Its RTG power source will provide at least one martian year of operation, including operation through one martian winter. Dr. Meyer discussed the science floor objectives for MSL and additional science objectives beyond the floor. The intent is to conduct analytical laboratory investigations, remote sensing investigations, contact instrument investigations, and other investigations based on the instruments selected for the rover. The Russian Space Agency will contribute a neutron detector instrument, to detect water within a meter or two of the martian surface. The Spanish Ministry of Science and Technology will contribute an onboard meteorology station.

An AO was released April 14, with a preproposal conference on May 4 and selection of science investigations in November. Proposals are due by July 15, 2004. There are no site selection requirements yet, but proposers will be guided by the mission goals set by the NRC's Space Studies Board in the latest Decadal Survey report. The MSL has to be able to go where those objectives can be achieved. Dr. Rummel remarked that a nuclear power source (RTGs) has the advantage of providing energy and power adequate to land on 80 percent of Mars. But it has the disadvantage of restricting the mission to much less than that because of planetary protection concerns for Mars special regions. Dr. Cavanaugh said that the MSL science floor includes looking for potential habitats for life on Mars but no life detection requirement. Dr. Meyer explained the rationale for not including life detection in the science floor, although life detection is not precluded from the investigations and instruments that could be proposed. A programmatic concern is not to make the detection of past or present life a criterion of mission success.

Dr. Meyer gave an overview of the current concepts for MSL mission sequence and the spacecraft configuration at launch and in its sky crane configuration for final descent and landing. Further information on the MSL acquisition program is available on the Internet at <centauri.larc.nasa/gov/msl>, <research.hq.nasa.gov>, and <spacescience.nasa.gov>.

Dr. Noonan explained to Dr. Meyer that some of the committee's concerns stem from its discussions about the window of time to conduct life detection investigations for extant life, before a human landing on Mars compromises evidence of extant life (if not of fossil life) in areas where humans are present. Dr. Meyer agreed with the importance of the issue but noted that too little is known about the best sites to look for life to focus MSL on that goal. There are plans for missions in the next decade that can do a better job of life detection using what is learned from MSL and the other near-term missions. He discussed with the PPAC the types of instruments that might contribute evidence, in either direction, on martian life and whether it came from Earth (forward contamination).

Dr. Meyer and the PPAC discussed the issue of the MSL or subsequent projects having to cover the cost of basic technology development to meet planetary protection requirements within the budget for an individual mission. A related problem is known technology that would be compatible with dry heat sterilization but is not commercially available or validated for spaceflight. Also discussed was the adequacy of the information that will be available to the MSL project to select the most promising site to investigate as a potential habitat for past or current life. Dr. Meyer suggested that some findings from MRO may be available in time to inform MSL

Discussion of Mars Requirements and MSL Planetary Protection

Dr. Rummel discussed with the PPAC the draft Executive Summary to the MSL project's justification for a COSPAR Category IV classification. Based on a set of assumptions and analyses about the mission, the project is requesting a IVa classification, with an additional provision that sample-access hardware that will contact the martian surface will meet the requirements for Category IVb. The probability of an off-nominal landing that would release significant numbers of microbes away from the impact site in a 100-year period was estimated to be less than 3×10^{-6}. Dr. Rummel requested comments from the PPAC members on the MSL draft justification and the accompanying letter from the Project Manager.

Dr. Noonan asked Dr. Meyer about the implications of an MSL instrumentation package that included some life detection capability beyond meeting the science floor requirements. There are substantial challenges in meeting the bioburden limit for the entire EDL package including the sky crane. Differences between the draft Executive Summary and the letter on whether MSL may target a martian special region reflect the likelihood that trades will be needed between engineering constraints on the mission and science interests. Differences between targeting a potential former habitat, such as Meridiani Planum, and a potential habitat for extant life (where liquid water or ice is near the surface now) were discussed. Dr. Rummel said that the MSL Science Definition Team was told the rover would not go anywhere that would require it to meet Category IVb requirements. He agreed with Dr. Meyer that, unless MRO provides break-through evidence for a site with high probability as a current life habitat, MSL is unlikely to go to a region where life detection would be a primary goal. That goal is now viewed as appropriate for subsequent missions such as the Astrobiology Science Laboratory or a MSR mission.

Dr. Noonan said that, from a planetary protection perspective, NASA has to decide whether MSL (or other landers) are going to sites that could be past habitats but without current life or sites that could have current life. To cover both kinds of habitat, two rovers are probably needed, each optimized for investigations related to one or the other type of site. Dr. Rummel said that, if MRO were to find a site with liquid water on or near the surface, the 2011 Scout mission would probably be planned to go there. It could use the same or similar technology to the 2009 MSL but would meet Category IVb standards. There was general agreement that NASA needs an advanced technology program to meet Category IVb standards, and this technology development burden should not be borne by any single mission, including the MSL project.

In response to a question about the acceptability of the form of argument used in the MSL classification justification, Dr. Stabekis said it would be useful to have the PPAC's view on the acceptability of the kind of analysis used. Is the form of the analysis acceptable as presented? Are there holes in the reasoning or uncertainties that should be addressed? Dr. Rummel agreed and added that he was interested in any comments from the PPAC on Mars planetary protection requirements. The members noted that a pitfall of the analytical approach is excessive optimism about the precision possible in the estimates of component factors in calculating an overall probability of contamination. Concerns were expressed that a project can simply work backward from the required P_C to what the component estimates need to be. Dr. Noonan asked to see more exploration of how to uncover or address "unknown unknowns" as mentioned in the Executive Summary under "What We Don't Know." Dr. Griner was concerned that the project might not select the best science investigations proposed because of engineering constraints. Dr. Rummel said he will continue to update the PPAC on the status of the MSL planetary protection classification. The immediate problem for the MSL project is a scenario in which the MSL lands in an area where subsurface ice could be melted by an off-nominal landing that in effect creates a special region and contaminates it. That scenario requires a higher standard of planetary protection.

Dr. Atlas said that, if a false positive from a life-detection investigation is the principal concern, then the objective should be to reduce the spacecraft's surface contamination as low as possible. The COSPAR requirement addresses the full burden including the embedded burden, but embedded burden would not be released unless a hard landing occurred. In that case, the MSL would not be conducting any life detection investigations. Dr. Rummel agreed, noting that the MSL project's categorization analysis focuses on special region concerns, rather than on whether a life detection capability would be affected. Other PPAC members commented on how to implement, in this context, the principle of protecting the window of time for answering the science question about life on Mars. In summarizing the discussion and closing the meeting, Dr. Noonan asked the members to provide Dr. Rummel with any additional comments at their earliest convenience.

PLANETARY PROTECTION ADVISORY COMMITTEE (PPAC)
NASA Headquarters and Lowe's L'Enfant Plaza Hotel
Washington, DC
June 10–11, 2004

AGENDA

Day 1—Thursday, 10 June 2004
Program Review Center, 9th Floor, NASA Headquarters
Washington, DC

8:30 a.m.	Welcome and Meeting Overview	Norine Noonan/John Rummel
8:35 am	Planetary Protection Program Update	J. Rummel
9:00 a.m.	Annual Ethics Briefing	General Counsel's Office
10:00 a.m.	Break	
10:15 a.m.	Solar System Exploration Overview	Andrew Dantzler, NASA HQ
11:15 a.m.	Current Status, ESA Missions	Gerhard Schwehm, ESA
12:00 p.m.	Lunch	
12:15 p.m.	Working Lunch/Communications Planning	Linda Billings, SETI Institute
1:00 p.m.	Mars Technology Program and Planetary Protection	Jim Cutts, JPL
2:00 p.m.	The Vision for Space Exploration	Michael Lembeck, NASA HQ
3:00 p.m.	Break	
3:15 p.m.	Space Microbiology and Human Missions	Elaine Akst, NASA HQ
3:45 p.m.	Discussion of Future Planetary Protection Challenges	J. Rummel
4:15 p.m.	Status of Planetary Protection Molecular Methods and their Application	J. Rummel
5:00 p.m.	Adjourn	
6:30 p.m.	Committee Dinner	701 Pennsylvania Avenue

Day 2—Friday, 11 June 2004
Caucus Room, Lowe's L'Enfant Plaza Hotel
Washington, DC

8:30 a.m.	Introduction to Discussion on Planetary Protection Standards	N. Noonan/J. Rummel
8:45 a.m.	Historical Overview of Forward Contamination Standards	Pericles Stabekis, Windermere Group
9:15 a.m.	Committee Discussion on Standards	
10:00 a.m.	Break	
10:15 a.m.	Committee Discussion Continues	
11:00 a.m.	Mars Sample Return Requirements / Back Contamination Standards	J. Rummel
12:00 p.m.	Lunch Break, American Grill, L'Enfant Plaza Hotel	
1:00 p.m.	Results from MER and other Mars Missions	James Garvin, NASA HQ
2:00 p.m.	NRC Mars Forward Contamination Study Status	Pam Whitney, NRC
2:15 p.m.	Status of MSL Planetary Protection Categorization	Michael Meyer, NASA HQ J. Rummel
2:45 p.m.	Mars Requirements and MSL Planetary Protection Discussion	N. Noonan
3:30 p.m.	Adjourn	

PLANETARY PROTECTION ADVISORY COMMITTEE MEMBERSHIP

Individual Members:

Dr. Norine E. Noonan, Chair
College of Charleston

Dr. John Rummel, Executive Secretary
NASA Headquarters

Dr. Ronald M. Atlas
University of Louisville

Dr. Robert Braun
Georgia Institute of Technology

Dr. Colleen M. Cavanaugh
Harvard University.

Dr. Carolyn S. Griner
Booz Allen Hamilton, Inc.

Dr. Debra L. Hunt
Duke University

Dr. John F. Kerridge

Mr. Alan Ladwig
Zero Gravity Corporation

Dr. Debra G. B. Leonard
University of Pennsylvania

Dr. Eugene H. Levy
Rice University

Dr. Carlé M. Pieters
Brown University

Dr. Susanna Hornig Priest
Texas A&M University.

Dr. George S. Robinson, III
Robinson & Associates Law Offices, P.C.

Dr. Diana Wall
Colorado State University

Dr. Laurie Zoloth
Northwestern University

Agency Representatives:

Dr. Michael H. Carr
U.S. Geological Survey

Dr. Paul Gilman
U.S. Environmental Protection Agency

Dr. David Klein
NIAID, National Institutes of Health

Dr. Richard Orr
U.S. Department of Agriculture; National Invasive Species Council

Dr. Robert A. Wharton
National Science Foundation

International Representatives:

Dr. Alain Berinstain
Space Exploration Program, Canadian Space Agency

Professor Akira Fujiwara
ISAS

Dr. Andrew J. Parfitt
CSIRO Australia Telescope National Facility

Dr. Gerhard Schwehm
ESA/ESTEC

Dr. Michel Viso
Centre National d’Etudes Spatiales (CNES)

PLANETARY PROTECTION ADVISORY COMMITTEE (PPAC)
NASA Headquarters and Lowe's L'Enfant Plaza Hotel
Washington, DC
June 10–11, 2004

MEETING ATTENDEES

Committee Members:

Noonan, Norine (Chair)	College of Charleston
Atlas, Ronald	University of Louisville
Braun, Robert	Georgia Institute of Technology
Cavanaugh, Colleen	Harvard University
Griner, Carolyn	Booz Allen Hamilton, Inc.
Hunt, Debra	Duke University
Kerridge, John	
Levy, Eugene	Rice University
Pieters, Carlé	Brown University
Priest, Susanna	Texas A&M University
Robinson, George	Robinson & Associates Law Offices, PLC
Rummel, John D. (Executive Secretary)	NASA Headquarters
Wall, Diana	Colorado State University

Agency Representatives:

Orr, Richard	U.S. Department of Agriculture; National Invasive Species Council
Klein, David	National Institutes of Health, NIAID

International Representatives:

Berinstain, Alain	Canadian Space Agency
Schwehm, Gerhard	European Space Agency (ESA)

NASA Attendees:

Akst, Elaine	NASA Headquarters
Cutts, Jim	JPL
Falcon, Andrew	NASA Headquarters
Lishansky, David	NASA Headquarters
Lomax, Terri	NASA Headquarters
McBride, Karen	NASA Headquarters
McNeill, Shera	NASA Headquarters
Norris, Marian	NASA Headquarters
Varsi, S.	NASA Headquarters
Vondrak, Richard	NASA Headquarters

Other Attendees

Billings, Linda	SETI Institute
Budden, Nancy Ann	Navy/LPI
Katt, Robert	INFONETIC
Kopecky, John	United Technologies Corp.
Stabekis, Pericles	Windermere
Whitney, Pamela	National Research Council

PLANETARY PROTECTION ADVISORY COMMITTEE (PPAC)
NASA Headquarters and Lowe's L'Enfant Plaza Hotel
Washington, DC
June 10–11, 2004

Presentation Slides Distributed in Hard Copy

1. John D. Rummel, Office of Planetary Protection, NASA. *Planetary Protection Update to the Planetary Protection Advisory Committee*, 10 June 2004.
2. Andrew Falcon, Office of General Counsel, NASA. *Ethics Briefing for Special Government Employees Serving on NASA Advisory Committees*
3. Andrew Dantzler, Deputy Director, Solar System Exploration Division, NASA. *Solar System Exploration*.
4. Gerhard H. Schwehm, Head of Planetary Missions Division, Directorate of the Scientific Programme, ESA. *Planetary Exploration in ESA, Status of Mars Express and Rosetta, Status of Planetary Protection Activities.*
5. Michael F. Lembeck, Director, Requirements Division, Office of Exploration Systems, NASA. *Office of Exploration Systems: Overview*.
6. Elaine Akst, Office of Biological and Physical Research, NASA. *Office of Biological and Physical Research: Microbial Studies*.
7. Linda Billings, SETI Institute. *(Draft) Risk Communication Plan for Planetary Protection*.
8. John D. Rummel, Office of Planetary Protection, NASA. *Status of PP Molecular Methods and their Application*.
9. Pericles Stabekis, Windermere Group. *Historic Overview of Forward Contamination Standards*.
10. John D. Rummel, Office of Planetary Protection, NASA. *Background for Discussion of Mars Sample Return Requirements and Back Contamination Standards*.
11. John A. Grant and Catherine M. Weitz, Mars Exploration Program, NASA. *The Mars Exploration Rovers: A View from the Front Seat*.
12. Michael Meyer, Mars Exploration Program. *Mars Science Laboratory*.
13. Mars Science Laboratory Project, Mars Exploration Program, NASA. *Mars Science Laboratory: Planetary Protection Categorization Justification White Paper*. *Executive Summary as of June 6, 2004*.

Other Materials Distributed at the Meeting

1. Norine E. Noonan, Chair, PPAC. Letter to Dr. Edward J. Weiler, Associate Administrator, Office of Space Science, May 26, 2004.
2. Margaret Race, Marvin Criswell, and John Rummel. Planetary protection issues in the human exploration of Mars. Paper Number 2003—1-2523.
3. Brian Berger. Moon-to-Mars Commission recommends major changes at NASA. *Space News* 10 June 2004.
4. Linda Billings and John Rummel. All of the planets, all fo the time: Planetary protection at NASA. *Space Times* January-February 2004, 12–15.
5. J.D. Rummel and L. Billings. Issues in planetary protection: policy, protocol, and implementation. *Space Policy* 2004; 20: 49–54.